DuPont Instruments

# 303 MOISTURE MONITOR

## OPERATING AND MAINTENANCE

PN 303103

**DuPont Instruments**

E. I. du Pont Co.
Instrument Products
Scientific & Process Division
Wilmington, DE 19898

# OPERATING and MAINTENANCE MANUAL for

# 303 MOISTURE MONITOR

PN 303103
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**This manual is a guide to the use of 303 Moisture Monitor**

Data herein has been verified and validated and is believed adequate for the intended use of the instrument. If the instrument or procedures are used for purposes over and above the capabilities specified herein, confirmation of their validity and suitability should be obtained, otherwise Du Pont does not guarantee results and assumes no obligation or liability. This publication is not a license to operate under, or a recommendation to infringe upon, any process patents.

*Notes, cautions, and warnings* within the text of this manual are used to emphasize important and critical instructions.

**WARNING:** An operating procedure, practice, etc, which, if not correctly followed, could result in personal injury.

**CAUTION:** An operating procedure, practice, etc, which, if not strictly observed, could result in damage of equipment.

**NOTE:** An operating procedure, condition, etc, which it is essential to highlight. *Health hazards precaution data.* If and when hazardous chemicals or adverse health factors affect the environment or use of the equipment, appropriate precautions are provided.

**WARNING**

The instrument is not recommended for use in hazardous locations.

**WARNING**

If the monitor is used to measure moisture in toxic or flammable gases, the SAMPLE OUT must exhaust to a safe place.

**WARNING**

Take care when handling acetone, alcohol, phosphoric acid, and nitric acid in the various procedures.

**WARNING**

*The service operations given or implied in this manual should be performed only by Du Pont or other qualified personnel.*

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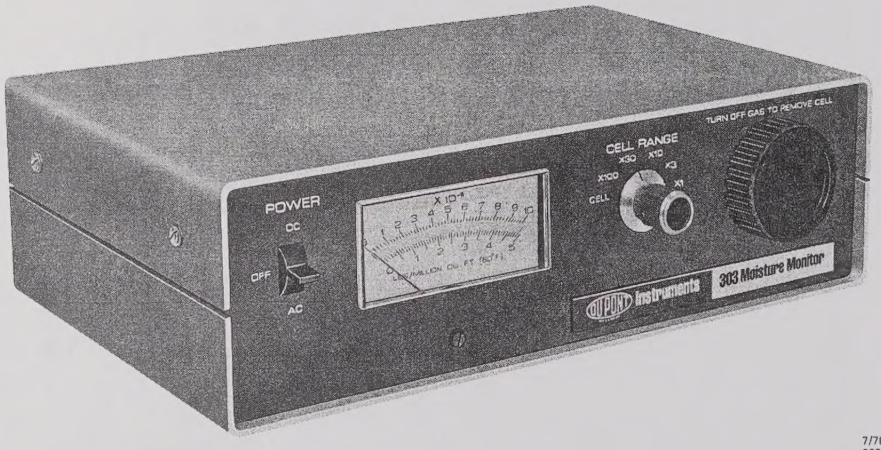


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*Figure 1-1. Du Pont 303 Moisture Monitor.*

# Section 1 GENERAL

## 1-1. SCOPE

This manual describes operation of the Du Pont 303 Moisture Monitor, provides application, installation, and maintenance data, and lists user replaceable parts. A glossary of terms is given at the end of the manual.

## 1-2. PURPOSE

The Du Pont 303 Moisture Monitor is designed to measure water vapor content of a gas or mixture of gases. It is not recommended for use in Class I, Division 1, 2 locations (hazardous atmospheres).

## 1-3. DESCRIPTION

The Moisture Monitor (figure 1-1) is a small, compact, portable instrument operated from an ac source or an internal battery. The front panel contains a power selector, an attenuation (range) control, a continuously reading meter calibrated in both parts per million by volume and lb/mmcf at 15.6°C [60°F], and an access cover for an electrolytic cell. The rear panel contains sample connectors, a flow control, recorder terminals, a recorder span control, an ac power connector, and a fuse receptacle.

## 1-4. SPECIFICATIONS

| | |
|---|---|
| Sample Pressure: | 0.7–7 bars (10–100 psig) |
| Sample Flow: | 100 $cm^3$/min, adjustable |
| Sample Temperature: | 10–50°C at sample inlet |
| Effect of Temperature Stability: | 0.3% per °C (temperature variations will change the sample flow causing an error not to exceed 0.3% per °C) |
| Sensitivity: | 10 parts per million and 0.5 lb/mmcf full scale on X1 range. |
| Accuracy: | ±5% of full scale on all ranges for a sample flow of 100 $cm^3$/min. |
| Dynamic Range: | 0—1 000 parts per million or 0—50 lb/mmcf [15.6°C (60°F)] for a sample flow of 100 $cm^3$/min. |
| Noise: | Less than 0.2 parts per million on X1 range, excluding transients. |

| | |
|---|---|
| Response Time: | 30 seconds or less for a 63% response to an increase from 50 parts per million and 5 minutes for a decrease from 1 000 parts per million to 50 parts per million. |
| Power Requirements: | a. 100 V ac, 50,60 Hz; 120 V ac 50,60 Hz; 240 V ac, 50,60 Hz; or 67.5 V dc Battery.<br>b. Power consumption – 10 watts nominal. |
| Dimensions: | 33.6 cm (13-¼ inches) wide x 24.1 cm (9-½ inches) deep x 10.2 cm (4 inches) high. |
| Weight: | Approximately 6.8 kg (15 lb) |

## 1-5. THEORY OF OPERATION

### a. General

A regulated gas stream containing water vapor passes through an electrolytic cell. The cell consists of two, parallel, helically wound, platinum electrodes mounted in a glass tube. A thin film of phosphorous pentoxide is deposited between the electrodes. Water vapor passing through the cell is absorbed by the phosphorous pentoxide. The extremely hygroscopic nature of phosphorous pentoxide, cell geometry, and proper flow control ensure complete absorption of all water vapor entering the cell.

A voltage applied to the electrodes causes electrolysis of the water vapor into molecular hydrogen and oxygen. The current generated by the electrolysis is directly related to the amount of water vapor by Faraday's Law. The current as parts per million and lb/mmcf is displayed on a meter.

### b. Functional

A block diagram of major component functions is shown in figure 1-2. The sample gas pressure must be at least 0.7 bar (10 psig) or a booster pump must be used. Foreign particles are filtered from the gas by filter discs. The flow controller (FLOW ADJUST) is adjusted to 100 $cm^3$/min. The built-in bypass system permits a portion of the sample gas stream to bypass the cell while 100 $cm^3$/min flow through the cell. Bypassing increases sample flow to the instrument, thereby reducing the time required for the sample to transit the sample line. Electrically, the cell is connected in series with an attenuated microammeter and a constant voltage dc power supply. Since sample flow is constant, the readout corresponds exactly and linearly to parts per million and lb/mmcf of water vapor in the sample stream.

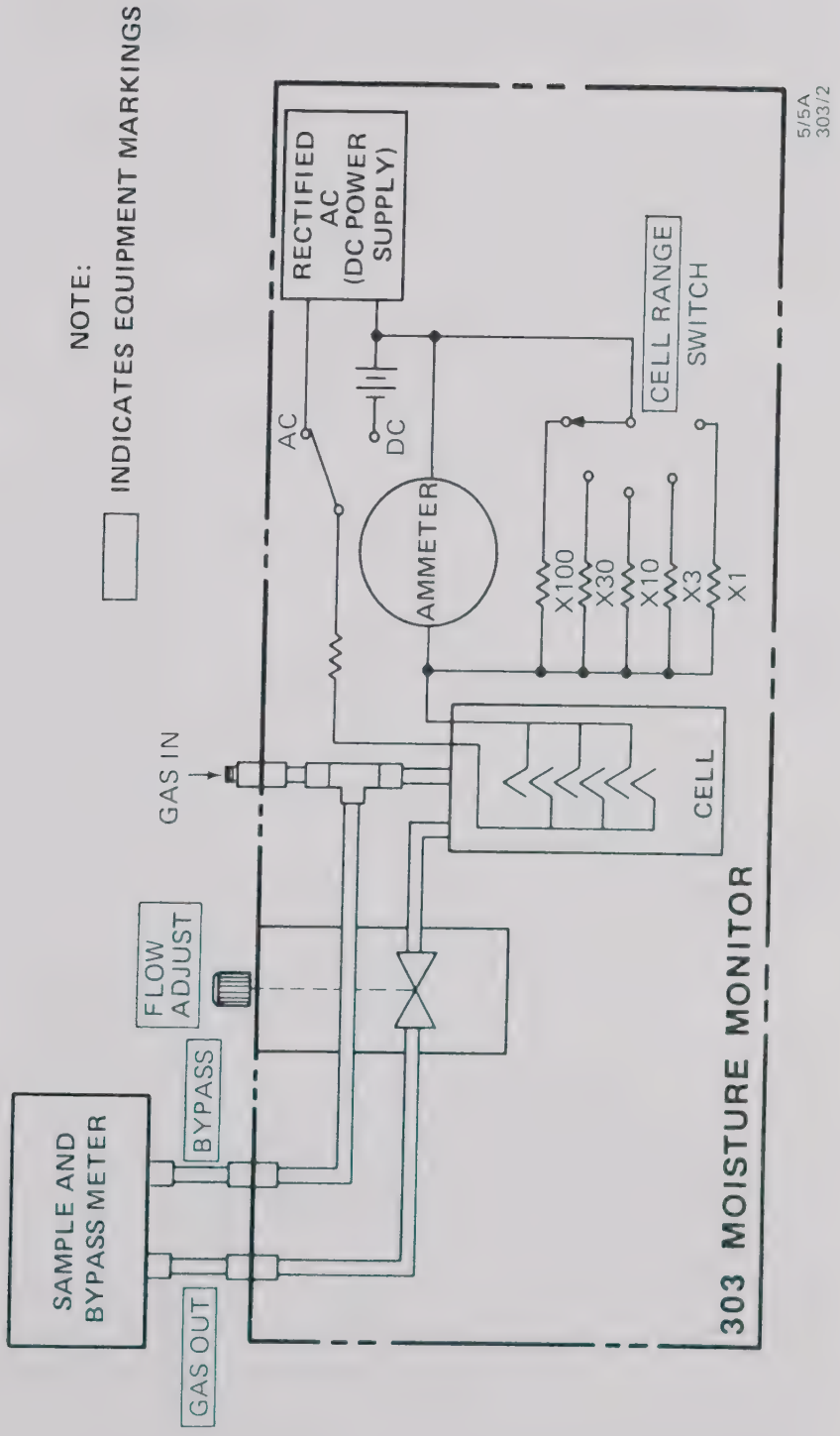



*Figure 1-2. Functional Block Diagram, Moisture Monitor.*

# Section 2 INSTALLATION

## 2-1. INSPECTION

Inspect the instrument for damage. It is the customer's responsibility to report shipping damage to the transportation company and to file a claim for damage. Check items received against the packing list. Report shortages to Du Pont.

## 2-2. REMOVING METER SHORTING WIRE

a. Remove the two screws on each side of the cover and lift off cover.

b. Loosen the two nuts (20), figure 4-1, and remove the shorting wire.

c. Tighten the nuts and re-install the cover.

## 2-3. INSTALLATION CONSIDERATIONS

When installing the moisture monitor, sampling technique is extremely important. Failure to observe necessary precautions can result in poor response, incorrect readings, or both. Be sure you do not plug the instrument in until all installation preparations are complete.

### a. Inlet Tubing and Connectors

The two most common installation errors are selecting improper sizes and materials for sample lines and fittings between the sample source and the instrument. To insure good results:

- Select a take-off point representative of the sample.
- Keep sample line short.
- Use no material in the inlet system which can absorb and desorb large quantities of moisture or allow permeation of moisture.

Stainless steel is preferred for sample system components, but copper and brass are acceptable. Most plastics or elastomeric materials are unsatisfactory because of their relatively high moisture permeability. Polycarbonate tubing can be used. All tubing should be minimum in size; 3.2 mm (1/8-inch) OD is recommended. Do not use pipe, rubber, or similar cements. American Sealants Co. Locktite, Grade A, can be used to seal leaks. The sample system should be leak-checked periodically.

### b. Optimizing Response Time

When the moisture monitor continuously samples a single stream it should be mounted as close as possible to the sample point. The approximate response

time can be calculated by dividing the sample flow (100 $cm^3$/min) into the estimated sample system volume. If the calculated response time is too great, the built-in bypass system can be used. Flow through the sample system should be as high as necessary to produce the desired response time. The bypass system is also valuable when the instrument is in portable service analyzing discrete samples. In these applications, the bypass system assists in purging gas cylinder valves, pressure regulators, and tubing prior to analyzing for moisture.

### c. Non-interfering, Interfering, and Contaminating Substances

**WARNING**

The instrument is not recommended for use in hazardous locations.

If the monitor is used to measure moisture in toxic or flammable gases, the SAMPLE OUT must exhaust to a safe place.

- Non-Interfering Substances

The cell is not affected by gases such as nitrogen, air, methane, and many aliphatic and aromatic hydrocarbons. The moisture monitor is ideally suited for the analysis of moisture in these gases.

- Interfering Substances

These substances cause an incorrect instrument reading but do not damage the cell. Typical examples are nitric oxide and Freon®22. Hydrogen and, under severe conditions, oxygen may cause incorrect readings. A special technique to correct for hydrogen and oxygen is described in paragraph 3-2, i.

- Contaminating Substances

These substances damage the instrument or cell. The instrument reading may or may not be immediately affected.

Certain corrosive acid gases will corrode the tubing and flow control system, but will not harm the cell. The instrument reading will not be affected until the damage is sufficient to cause line leakage, poor flow control, etc. Typical examples are chlorine and sulfur dioxide.

Certain hydrocarbons gradually coat the cell with a polymeric coating. The reading is gradually affected as the cell becomes inactive. A typical example is butadiene.

Entrained liquids and solids can also affect cell performance. Filtering usually prevents this problem.

Do not allow liquids to pass through the cell. They will wash away the phosphorous pentoxide coating.

- Interfering and Contaminating Substances

Some substances will immediately interfere with the proper reading and cause additional errors as they contaminate the system. Typical examples are graphite dust, hydrogen fluoride, and ammonia.

## 2-4. SAMPLE STREAM REQUIREMENTS

- Contaminating substances should be removed from sample if possible.
- All particulate matter larger than 10 $\mu$m must be filtered out.
- The sample temperature must not exceed 50°C.
- The sample must be free of oil mist.

## 2-5. CHECK-OUT

a. Unscrew the cell cap and insert cell (303029-901) with filter discs (303027-901) seated on both ports. It may be necessary to turn the cell for proper engagement. Screw cap firmly in place.

b. Connect a source of gas at 0.7 to 7 bars (10 to 100 psig) with a moisture content of less than 1 000 parts per million to the GAS IN fitting. Nitrogen, air, argon, or helium are commonly used.

c. Connect a flowmeter such as the Bubble-O-Meter or sample and bypass flowmeter to the GAS OUT fitting (figures 2-1 thru 2-4). If a sample and bypass flowmeter or an external rotameter is used, it must be calibrated for the sample gas. The Bubble-O-Meter needs no calibration.

d. Adjust the FLOW ADJUST to 100 $cm^3$/min to insure that the lines are free and that proper flow can be obtained.

e. Close the FLOW ADJUST for the following power hookup and electrical check:

**CAUTION**

The proper voltage and frequency for the monitor is either 100, 120, or 240 V ac and 50 or 60 Hz. The label on the back panel specifies the proper power requirements. Unplug the line cord when you install the battery.

- If a battery is to be used for check-out, remove the cover, install it, and proceed to step e.
- If ac is to be used, connect the power cord to the instrument and to the proper ac source.

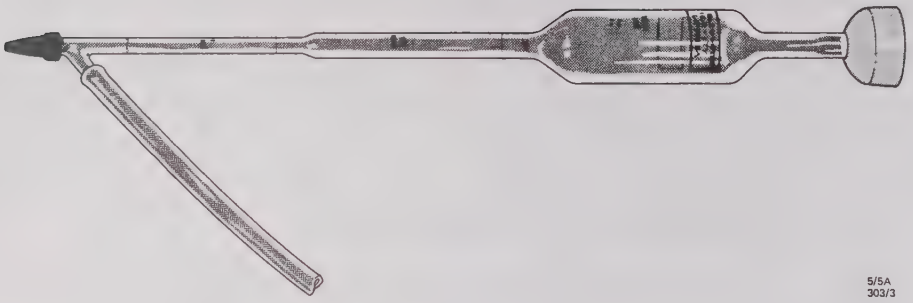



*Figure 2-1. Bubble-O-Meter.*

f. Set the POWER switch to the appropriate setting (AC or DC) and turn the CELL RANGE switch to CELL.

In the CELL position the meter reads dc voltage across the cell. Twenty volts are required for full-scale deflection. With the POWER switch at AC or DC and with no sample flow, electrolysis will gradually *dry* the cell causing the meter to move upscale. Wait for the meter to peg upscale before proceeding to step f.

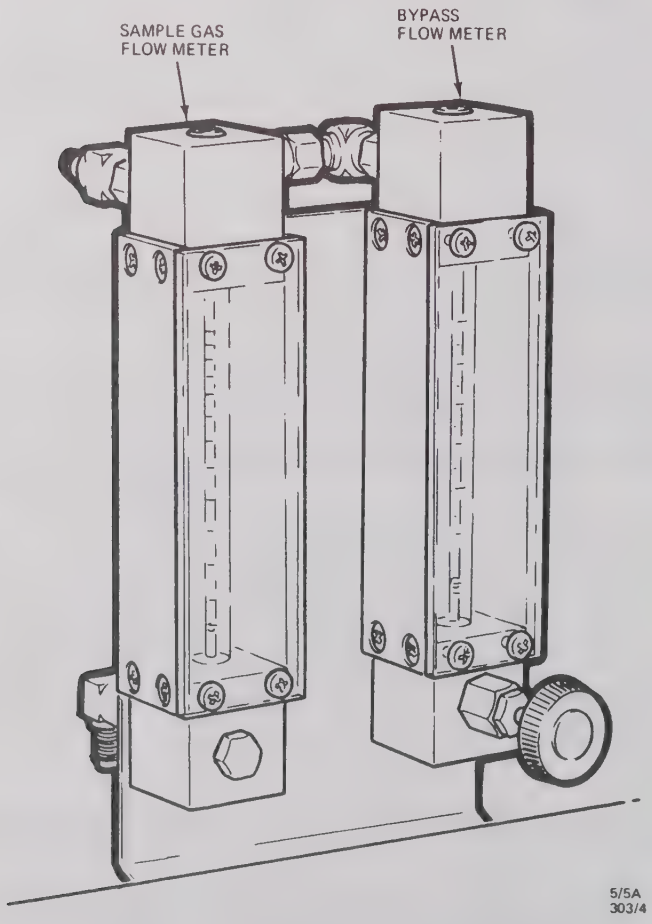



*Figure 2-2. Sample and Bypass Meter.*

g. Adjust the FLOW ADJUST valve to 100 $cm^3$/min.

h. Turn the CELL RANGE switch to the lowest range that does not cause the meter to peg.

i. Continue to operate the monitor until the system stabilizes.

j. If the monitor is operating on ac, and if a battery is installed, set the POWER switch to DC. The meter should move slightly down scale. This slight difference between ac and dc operation is normal and will disappear after the equipment has been in operation for a short period of time.

k. If the instrument is operating correctly, turn off the sample gas and set the POWER switch to OFF. If the instrument is not operating correctly, review the previous portion of the manual to ensure that the procedures have been followed properly, and read the following portions of the manual. Troubleshooting procedures are in Section 4.

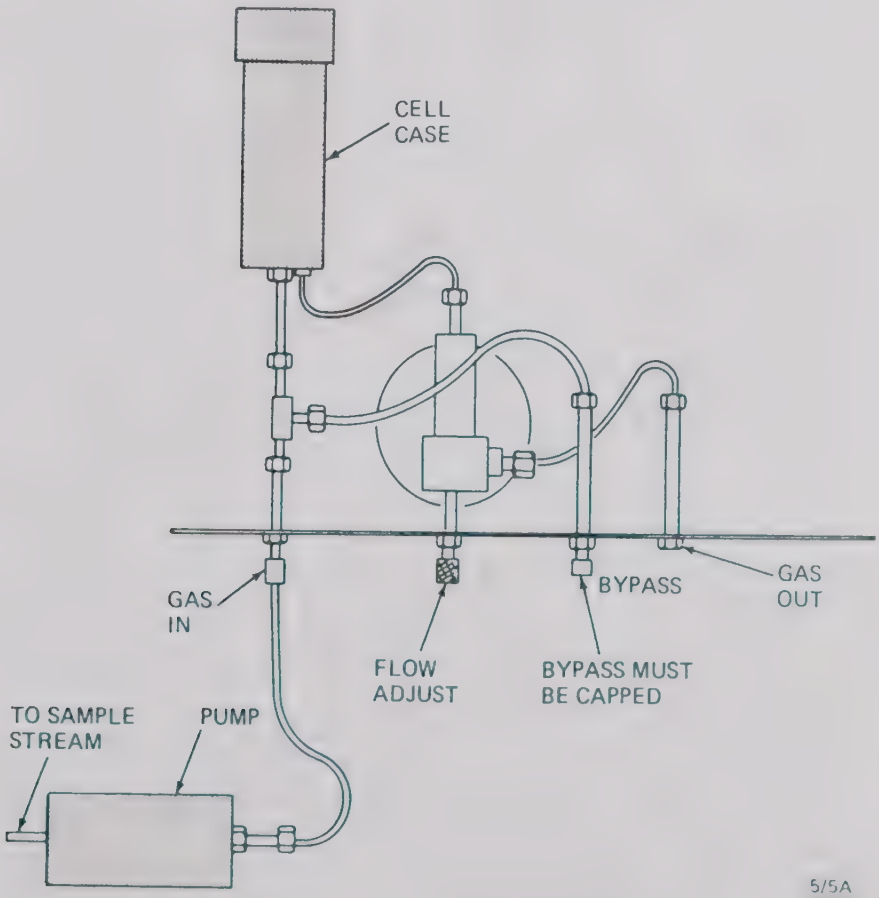



*Figure 2-3. Installation Diagram, Moisture Monitor.*

## 2-6. INSTALLATION

**WARNING**

The instrument is not recommended for use in hazardous locations.

If the monitor is used to measure moisture in toxic or flammable gases, the SAMPLE OUT must exhaust to a safe place.

Refer to figure 2-3 or 2-4 and connect the monitor as necessary for your operation.

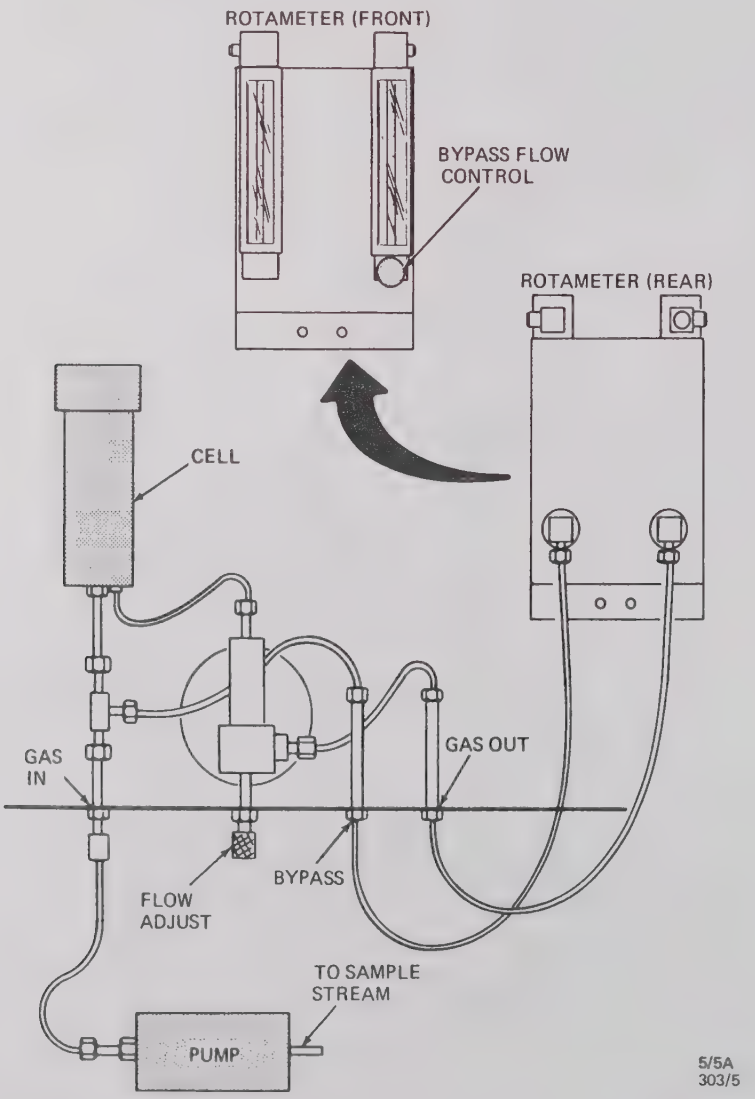



*Figure 2-4. Installation Diagram, Moisture Monitor with Bypass System.*

# Section 3 OPERATING INSTRUCTIONS

## 3-1. CONTROLS AND INDICATOR

a. **Front Panel** (figure 3-1).

| CONTROL | POSITION | FUNCTION |
|---|---|---|
| 1. POWER | OFF | No power to the instrument circuits. |
| | AC | Applies external ac to the circuits. |
| | DC | Applies battery power to the circuits. |
| 2. CELL RANGE | CELL | Causes meter to read cell voltage (20 V full scale). |
| | X100/X30/X10/X3/X1 (range) | Attenuates meter current. |
| 3. METER | | Shows moisture content in PARTS X $10^{-6}$ by Volume and LBS/MILLION CU FT [15.6°C (60°F)] and cell voltage (20 V max.) |

b. **Rear Panel** (figure 3-2).

| CONTROL | POSITION | FUNCTION |
|---|---|---|
| 1. RECORDER | Variable | Adjusts instrument output to recorder (0–100 mV). |
| 2. FLOW ADJUST | Variable | Adjusts and controls sample flow. |

## 3-2. PARAMETERS AFFECTING OPERATION

a. **Calibration**

The moisture monitor does not require calibration because the measurement is quantitative and the analyzer response to moisture is linear from less than 1 part per million to 1 000 parts per million.

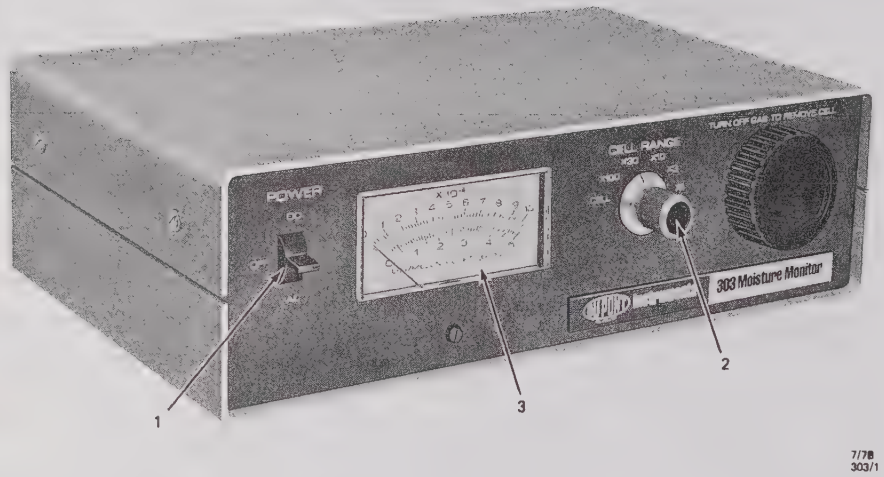



*Figure 3-1. Controls and Indicators of Moisture Monitor, Front View.*

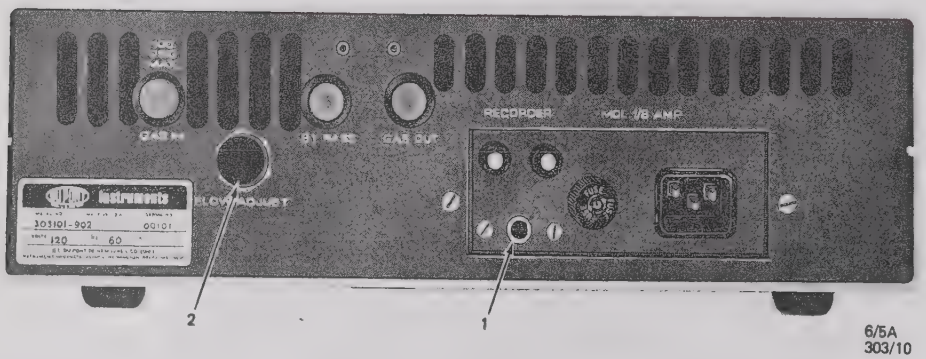



*Figure 3-2. Controls and Indicators of Moisture Monitor, Rear View.*

**b. Flow**

The instrument is designed for a sample flow of 100 $cm^3$/min at atmospheric pressure and 25° C.

Operation at a flow other than 100 $cm^3$/min requires a meter reading correction to obtain the proper parts per million. In general, doubling the flow doubles the correct moisture level reading.

c. Density

Sample flow must be readjusted if gases of different densities are analyzed.

NOTE

The indicator of a rotameter will not be at the same point for a flow of 100 $cm^3$/min for two gases having different densities. Rotameters are calibrated for a specific gas at a specific temperature and pressure. Volumetric flow measuring devices such as the Bubble-O-Meter are not affected by different gas densities and will provide the correct flow independent of density (at constant temperature and pressure).

d. Pressure

Sample input pressure does not affect instrument response since the flow controller maintains a constant flow. Pressure is normally regulated from 0.7 to 7 bars (10 to 100 psig), but the monitor can accommodate higher sample gas pressures if an external regulator is used to reduce the pressure to the 0.7 to 7 bar range.

Gas usually exits the system at one atmosphere. If the monitor is operated with a back pressure, an appropriate correction must be made to the flow measuring devices being used to ensure that flow through the monitor corresponds to 100 $cm^3$/min at atmospheric pressure and 25°C.

e. Temperature

A change in sample temperature does not affect the operation. However, it does affect the density of the gas and as previously noted, this change requires a readjustment to ensure that the sample flow is equivalent to 100 $cm^3$/min at atmospheric pressure and 25°C.

In actual practice, however, it is often more common to correct the reading rather than the flow. At room temperature (25°C, 298 K), the disassociation of 1 part per million or water vapor produces a 13.2 $\mu$A cell current at 100 $cm^3$/min. At other temperatures, the current produced is 13.2 $\mu$A times the ratio of 298 K to the temperature in K. Thus, the correction to be applied to an instrument calibrated at room temperature is about 0.3% per degree C. Instrument readings must be increased by this amount for temperatures above 25°C, and decreased for temperatures below 25°C.

A temperature rise any place upstream from the cell may cause an upward transient response resulting from tramp water being driven from the internal walls of the sample system tubing and fittings. A temperature drop may produce a similar downward transient. The size of transients associated with tramp water will usually be more noticeable if the lower dynamic ranges are being used. The system should be sheltered from drafts or protected from possible temperature changes.

### f. Instrument/Sampling System Equilibration

When sampling a stream with a given moisture content, the sample, the sample system, and the instrument reach a state of equilibrium. If moisture level of the sample changes, a finite time is required for the system to again equilibrate. This time is a function of the flow rate through the monitor, the effective surface area of the sample system, and the sample temperature. Obviously, the sample system should be kept as simple as possible so that equilibration time is minimized.

The moisture monitor is often used to evaluate the moisture content of individual samples such as cylinder gas. This type of analysis often requires that the sample tubing be exposed to the atmosphere when changing the sampling point from one cylinder to another. Each time open tubing is exposed to the atmosphere, a period of time is required for the total system to again reach equilibrium. With careful operation, one can obtain accurate data in about 15 minutes.

When analyzing samples of very low moisture content, an important factor affecting the operation and accuracy of the total system is the time to reach equilibration.

Process lines, cylinder valves, sampling tubes, and intermediate sampling containers are all susceptable to absorption and desorption of water. Consider the following suggestions when analyzing for low moisture levels:

- Eliminate moisture absorbing materials.
- Minimize the system's interior surface by using 3.2 mm (1/8-inch) tubing.
- Insulate the system to prevent large temperature swings.
- Maintain good pressure control within the system.

### g. Line Voltage Variations

Line voltage variations up to ±10% will not affect instrument operation since its power supply is dc regulated. The nominal no-load cell voltage is 75 V dc on ac operation and 67 V dc on battery operation. The exact value is not critical.

### h. Transportation

When the monitor is being moved from place to place, a battery should be installed and the POWER switch set to DC. This provides a low current to keep the cell *dry* through electrolysis. Cell equilibration time prior to the next analysis is then reduced. This current draw will not significantly discharge the battery. The GAS IN and GAS OUT fittings should be capped to prevent moisture and dirt from entering the lines.

i. Hydrogen and Oxygen Streams

**WARNING**

If monitor is used to measure moisture in toxic or flammable gases, the SAMPLE OUT must exhaust to a safe place.

When analyzing for moisture vapor in hydrogen, oxygen, or gas mixtures that contain high percentage of either gas, the meter will read artifically high. The high reading is a result of electrolysis of moisture formed by the recombination of free hydrogen or oxygen.

Sample streams having a high concentration of hydrogen will promote the formation of moisture by combining the free oxygen generated by electrolysis with the hydrogen. This moisture is then electrolyzed causing a high reading. Sample streams having a high concentration of oxygen also promote recombination, but to a smaller degree. Generally, the error resulting from air or oxygen streams is insignificant if the actual moisture content exceeds 20 parts per million.

The effect of electrolyzed reformed water can be easily determined. The reformation of water is constant and independent of flow within the range of the monitor. Use the following technique to correct for this effect:

(1) Adjust the sample flow to 100 $cm^3$/min and note the moisture content

(2) Readjust the flow rate to 200 $cm^3$/min and note the moisture content. The difference between these two readings is the true moisture level.

## 3-3. OPERATING PROCEDURE (CHECKLIST)

With the monitor connected to a sample gas stream, proceed as follows:

a. Set the POWER switch to either AC or DC.

b. Turn the CELL RANGE selector to CELL.

c. Check sample gas for the following:

(1) Pressure: 0.7–7 bars (10–100 psig)

(2) Flow: 100 $cm^3$/min.

(3) GAS IN temperature: Between 10° and 50°C.

**NOTE**

Refer to paragraph 3-2, e. for temperature variation correction factor.

d. Select the highest range (x 100) and wait for the reading to stabilize.

NOTE

To prevent cell saturation, always turn the sample gas off before turning the instrument off.

## 3-4. STANDBY OPERATION

It is advisable to leave the power on and permit a low flow (5–100 $cm^3$/min) of dry nitrogen or similar gas through the instrument when it's not in use. This reduces equilibration time by keeping the sample system and cell relatively dry. If the instrument is to be turned off for an extended period, remove and cap the cell with the protective shipping cap.

# Section 4 MAINTENANCE

WARNING

*The service operations given or implied in this manual should be performed only by Du Pont or other qualified personnel.*

## 4-1. GENERAL

The frequency of analyzer maintenance depends almost entirely on the condition of the sample stream being monitored. A clean sample stream will provide months of troublefree analyzer operation, while a dirty stream can cause the analyzer cell to fail in minutes.

CAUTION

- Before disconnecting any tubing, or removing the cell, shut off sample flow.
- Before shutting the instrument off electrically, shut off sample flow.

WARNING

- Take care when handling acetone, alcohol, phosphoric acid, and nitric acid in the various procedures.

## 4-2. TOOLS AND MATERIALS REQUIRED:

No special tools are required.

## 4-3. PARTS REPLACEMENT

a. **Cell Case** (figure 4-1).

(1) Shut off sample gas flow.

(2) Turn the POWER switch to OFF. Unplug the line cord.

(3) Remove the two screws on each side and lift off cover.

(4) Remove the cell case cover (1) and pull the cell out by its tab.

(5) Carefully unsolder the leads (2) from the terminals.

(6) Loosen the two ferrule nuts (3) and disconnect the lines.

(7) Pull the cell case (4) forward through the front panel.

b. **O-Ring Seal** (figure 5-3).

(1) Proceed as directed in paragraph 4-3, a, steps (1) thru (5), except do not unsolder the leads.

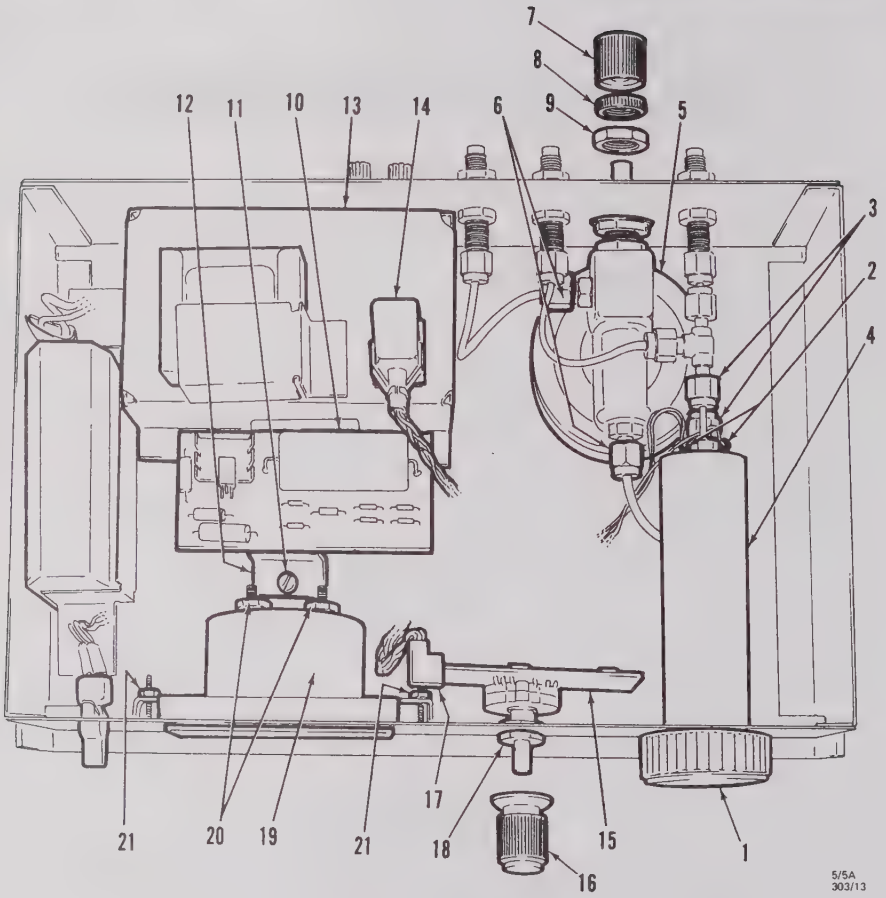



*Figure 4-1. Moisture Monitor, Interior View.*

(2) Unscrew the two nozzles from the cell case.

(3) Remove the O-rings from the nozzles and install new rings.

c. **Flow Controller** (5, figure 4-1).

(1) Proceed as directed in paragraph 4-3, a, steps (1), (2) and (3).

(2) Loosen the two ferrule nuts (6) and disconnect the lines.

(3) Loosen the setscrew (7) in the FLOW ADJUST control knob and remove the knob.

(4) Remove the knurled nut (8) and the panel nut (9).

(5) Lift out the flow controller.

d. **Power Regulator PC Board** (10, figure 4-1).

(1) Proceed as directed in paragraph 4-3, a, steps (1), (2), and (3).

(2) Remove the screw (11) holding the retaining bracket (12).

(3) Slide the regulator pc board forward from its connector.

e. **Power Regulator Assembly** (13, figure 4-1).

(1) Proceed as directed in paragraph 4-3, b.

(2) Pull the connector (14) from the power regulator assembly.

(3) Remove the two retaining screws (1, figure 5-2) from the rear and one screw (2) from the bottom of the instrument.

(4) Disconnect the battery and lift out the power regulator assembly.

f. **Attenutator Switch PC Board** (15, figure 4-1).

(1) Proceed as directed in paragraph 4-3, a, steps (1), (2), and (3).

(2) Loosen the two setscrews (16) in the CELL RANGE knob and remove the knob.

(3) Unplug the connector (17) from the attenuator switch pc board.

(4) Unscrew the panel nut (18) from the shaft and slide the switch assembly out the rear of the panel.

g. **Meter** (19, figure 4-1).

(1) Proceed as directed in paragraph 4-3, a, steps (1), (2), and (3).

(2) Remove the two nuts (20) and disconnect the wires from the meter.

(3) Loosen the two nuts (21) holding the meter clamp, move the clamp out of the way, and pull the meter out.

## 4-4. SAMPLE FLOW REGULATOR CLEANING

Replacement flow controllers are supplied by Du Pont as complete units. Replacement parts, if required, must be obtained from the manufacturer. All internal adjustments are important and care should be taken to return all parts to their proper position after cleaning. Frequency of cleaning and solvents used depend on the contaminating material. Proceed as follows:

CAUTION

Do not use aromatic organic solvents to clean the neoprene regulator diaphragm.

a. Remove the flow controller (paragraph 4-3, c).

b. Remove the six capscrews with a 5/32-inch hex wrench.

c. Remove the 3/4-inch nut and the control shaft.

d. Carefully clean all metal parts using appropriate solvents (Freon® TF, etc). Pay particular attention to the condition of the ball and seat the spring-loaded bleed valve.

e. Wash thoroughly with acetone and blow completely dry with dry nitrogen or air.

f. Reassemble immediately to prevent condensation of ambient moisture. Store in a dry area.

## 4-5. CELL CLEANING, FLUSHING, AND RECOATING.

The cell coating may be contaminated, dirty, covered with oil, or washed out by introduction of liquid. These conditions are indicated by a low reading on a known gas.

Particulate matter may cause a short or a partial short. Shorts are indicated by a meter reading of 0 to 1 (2 volts or less) on the 0 to 10 scale with the CELL RANGE switch at CELL; or, a noisy or steady high reading on a known dry gas. Regardless of whether the cell is shorted, contaminated, or washed out, it needs to be replaced or repaired. New cells are available from Du Pont or cell may be repaired as follows:

**NOTE**

This procedure must be done under laboratory conditions. Chemicals and solvents used must be chemically pure, reagent grade, and free from particulate matter. The syringe and O-ring used (figure 4-2) must be free from contamination and foreign matter.

a. Use a hypodermic syringe (figure 4-2) and flush the cell with distilled water. Do not use a needle on the syringe. Insert the small end of the syringe into the cell port with just enough force that the O-ring makes a good pressure seal.

b. Flush the cell with acetone, alcohol, or other suitable solvent to remove contaminants.

c. Repeat with distilled water and with acetone. This flushing renders the cell inactive.

d. Blow the acetone from the cell with dry air.

e. Place the cell in the monitor with sample flow off. If the reading is more than 1 part per million, rewash the cell (step a). If the reading is less than 1 part per million, recoat the cell as follows:

(1) Prepare a solution of 2 parts of phosphoric acid to 8 parts acetone by volume.

**CAUTION**

The phosphoric acid (85% $H_3PO_4$ in water) and acetone must be chemically pure, reagent grade. The solution must be freshly prepared.

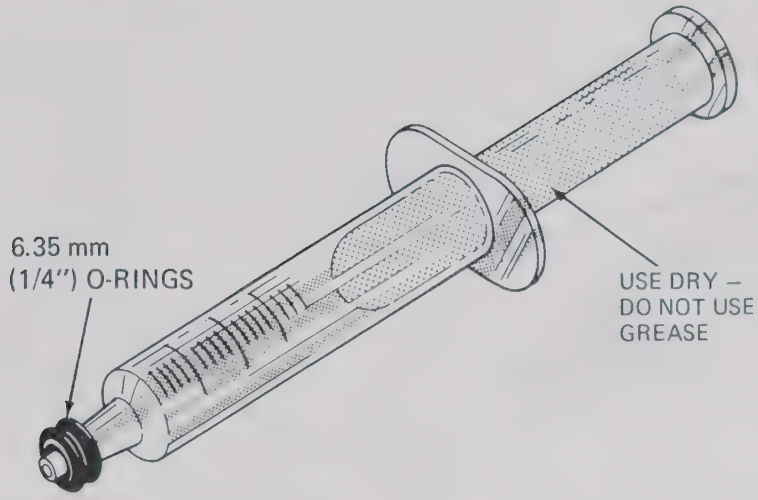



*Figure 4-2. Syringe Used for Cell Flushing.*

(2) Use a clean hypodermic syringe and fill the cell with the coating solution.

(3) When the cell is completely filled, withdraw the solution with the syringe.

(4) Pass about 100 $cm^3$/min of dry gas (air, $N_2$, etc) through the cell for 15-20 minutes to evaporate the acetone. Acetone must be completely removed from the cell before using it. A thin coating of phosphorous pentoxide will remain.

(5) After the acetone is completely removed, place the cell in the monitor and run an analysis until the meter stabilizes. Stabilization may take 3 to 4 hours. If the reading does not stabilize, the cell may be shorted. Refer to step f. below.

f. Remove a short circuit as follows:

(1) Fill the cell with concentrated nitric acid and let stand for 0.5 hour.

(2) Flush several times with distilled water and follow with acetone.

(3) Test the cell (step e). If the short is removed, recoat the cell (step e). If not, proceed to step (4).

(4) Connect one of the spring contacts of the cell to an electrical ground (water pipe) (figure 4-3).

(5) Connect the Tesla coil to an ac source.

**CAUTION**

Attempting to burn out a short using a Tesla coil should only be used as a last resort. There is a chance you may melt an electrode and ruin the cell.

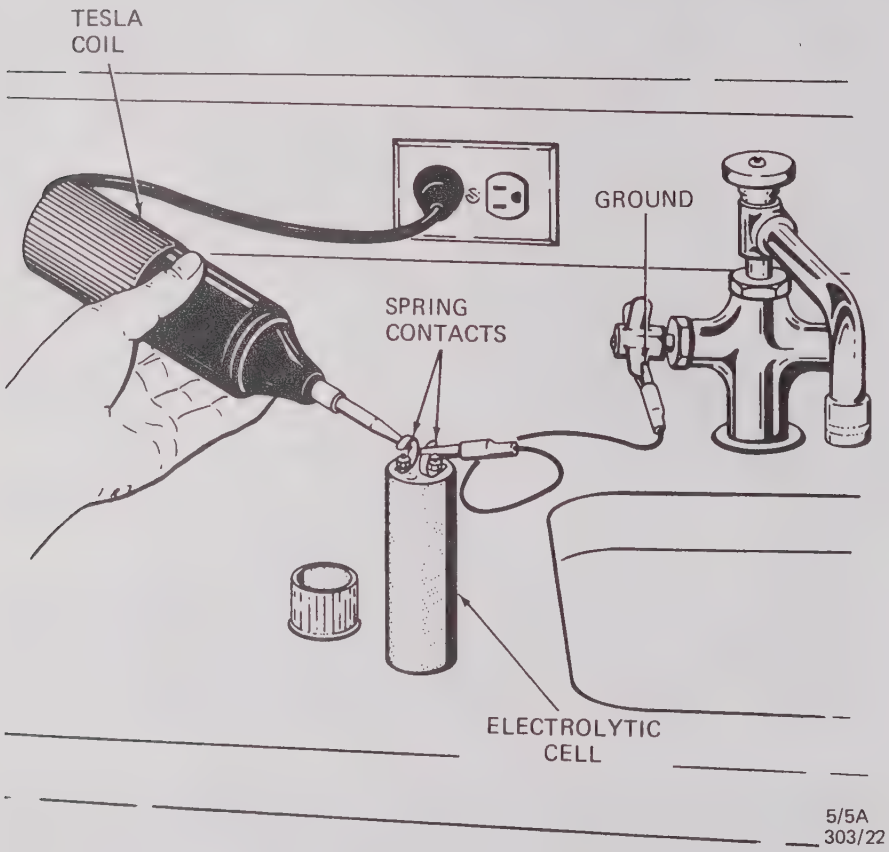



*Figure 4-3. Use of Tesla Coil to Remove Shorts.*

(6) Adjust the Tesla coil until it produces a 6 to 13 mm (1/4 to 1/2-inch) spark.

(7) Touch the coil probe to the ungrounded spring cell contact.

(8) Test the cell (step e). If the meter reads between 0 and 1 part per million, recoat the cell. If the meter reads 0, you probably melted an electrode and you must replace the cell.

## 4-6. TESTING.

### a. Operational Test

Check sample gas flow control as follows:

(1) Inspect all fittings for tightness.

(2) Connect a flowmeter such as a Bubble-O-Meter or rotameter to the GAS OUT fitting. The Bubble-O-Meter is preferred because of its greater accuracy.

(3) Adjust sample gas pressure to about 3.4 bars (50 psig).

(4) Vary the sample gas pressure between 1.4 and 6.9 bars (20 and 100 psig) and check that the flow does not vary more than ±5%.

b. Electrical Test

The following test will ensure that the instrument is operating properly electrically.

(1) Connect the power cord to an ac outlet.

(2) Turn the CELL RANGE selector to CELL.

(3) Set the POWER switch to AC.

NOTE

The meter will read the voltage across the cell. As the cell dries down, cell voltage will approach 70 volts. Twenty volts are required for full-scale deflection in the CELL position.

(4) Admit a sample gas and adjust flow to 100 $cm^3$/min.

(5) Turn the CELL RANGE selector to X100. The meter should read full scale initially and come on scale as the cell dries down.

(6) Remove the top cover and check for about 20 V dc between C1 (+) and C2 (–) on the power regulator pc board.

(7) Turn the CELL RANGE selector to CELL and continue to operate the instrument. When the meter pegs, turn the CELL RANGE selector to X100. The meter should quickly read on scale.

(8) Let the instrument operate until the reading stabilizes.

## 4-7. TROUBLESHOOTING (figure 4-4).

WARNING

*The service operations given or implied in this manual should be performed only by Du Pont or other qualified personnel.*

Troubleshooting table 4-1 localizes a faulty assembly. It is not intended to isolate a faulty component.

*Table 4-1. Troubleshooting Chart*

| Symptom | Possible Cause | Corrective Action |
|---|---|---|
| 1. Meter reads 0 on all positions of CELL RANGE selector. | a. Power cord not plugged in. | a. Plug in power cord. |
| | b. POWER switch OFF. | b. Set POWER switch to AC. |
| | c. Blown fuse. | c. Replace fuse. |

*Table 4-1. Troubleshooting Chart (cont'd.)*

| Symptom | Possible Cause | Corrective Action |
|---|---|---|
| | d. Faulty transformer T1 or switch S1. | d. Set POWER switch to OFF, remove connector from rear of analyzer, set POWER switch to AC, and check continuity of S1 and T1 using schematic diagram (figure 4-4). |
| | e. Faulty power regulator pc board. | e. Measure dc between C2 (–) and C1 (+). If voltage is not present, replace pc board. If voltage is present, proceed to step f. |
| | f. Faulty meter M1. | f. Disconnect meter terminals. Check for continuity and deflection with an ohmmeter. If continuity is not present, replace M1. If continuity is present, proceed to step g. |
| | g. Faulty attenuator switch pc board. | g. Replace attenuator switch pc board. |
| 2. Meter reads 0 in all but CELL position of CELL RANGE selector. | a. Cell terminals not making contact. | a. Remove cell and check for bent spring contact. Straighten spring, if bent. Clean contacts. |
| | b. Open Cell. PN 133137 SN 80216 | b. Remove cell and check continuity. If continuity is not present, replace cell. |
| | c. Open Circuit. | c. Remove power and test for continuity using schematic diagram. Repair open circuit. |
| 3. Meter reads full-scale. | a. Temporarily saturated cell. | a. Switch to lowest range where a mid-scale reading is obtained, note if reading decreases and wait for a normal reading. If normal reading is not obtained in 1 hour, proceed to step b. |

*Table 4-1. Troubleshooting Chart (cont'd.)*

| Symptom | Possible Cause | Corrective Action |
|---|---|---|
| | b. Saturated cell. | b. Shut off sample flow and allow cell to dry down. Keep it operating electrically. |
| | c. Shorted cell. | c. Remove cell and correct short (paragraph 4-5, f). |
| | **NOTE** Shorts are indicated by a meter reading of 1 or less on the 1 to 10 scale with the CELL RANGE selector at CELL. | |
| 4. Erratic meter reading (noisy). | a. Varying sample flow. | a. Remove flow regulator and clean (paragraph 4-4). |
| | b. Intermittent short. | b. Remove cell and repair short (paragraph 4-5, f). |
| | c. Faulty power regulator pc board. | c. Replace power regulator pc board. |
| 5. Meter reading low on a gas with a known moisture content. | a. Low gas flow rate. | a. Check and adjust flow rate (paragraph 4-6). |
| | b. Dirty flow regulator or clogged filter disc. | b. Remove flow regulator and clean (paragraph 4-4). Remove cell and replace filter discs. |
| | c. Contaminated or dirty cell, or partially inactive phosphorous pentoxide. | c. Remove, flush, and recoat cell (paragraph 4-5). |
| | d. Faulty attenuator switch pc board. | d. Replace attenuator switch pc board. |
| 6. Meter reading high on gas with a known moisture content. | a. High gas flow rate. | a. Check and adjust flow rate (paragraph 4-6, a). |

*Table 4-1. Troubleshooting Chart (cont'd.)*

| Symptom | Possible Cause | Corrective Action |
|---|---|---|
| | b. Dirty flow regulator. | b. Remove flow regulator and clean (paragraph 4-4). |
| | c. Shorted or partially shorted cell. | c. Remove cell, flush, and re-coat (paragraph 4-5). |
| | d. Faulty attenuator switch pc board. | d. Replace attenuator switch pc board. |

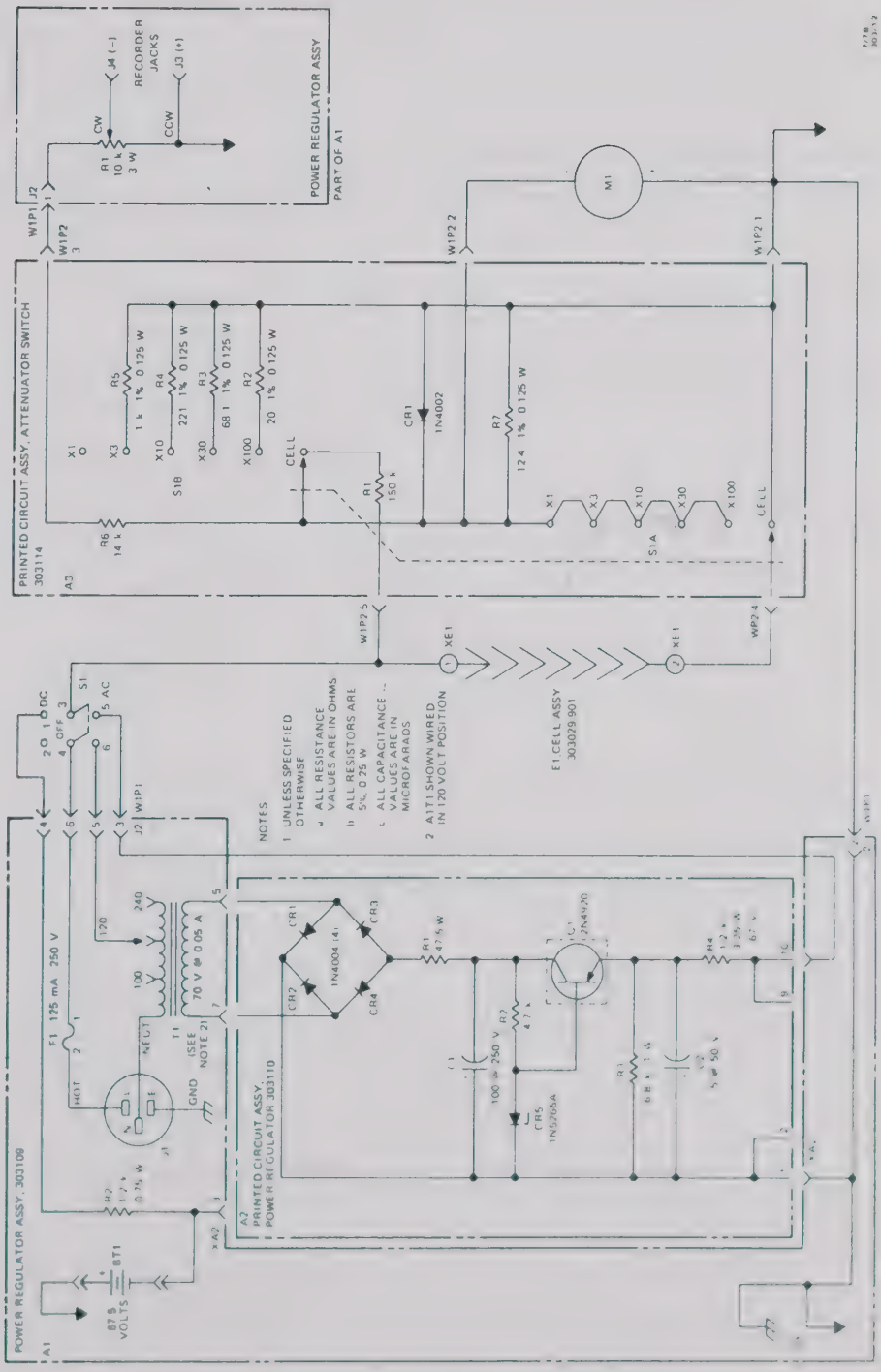



*Figure 4-4. Schematic Diagram, Moisture Monitor.*

# Section 5 PARTS LIST

## 5-1. INTRODUCTION

This section lists the parts which Du Pont considers practical to stock and supply for replacement. The parts are identified by reference designation or item number in figures 5-1, 5-2, and 5-3.

## 5-2. INDENTION

Parts in these lists are indented to indicate item relationships. The following is an example of the indentation system used in the description column.

Assembly and/or Component.

- Detail Part or Subassembly of Assembly and/or Component
- Attaching Hardware (if applicable) for Detail Part or Subassembly
- • Parts of Detail Part or Subassembly
- • Attaching Hardware (if applicable) for parts
- • Attaching Hardware (if applicable) for Assembly or Component.

Normally, only special attaching hardware is listed. Except for any special item, all hardware is stainless steel in standard sizes that can be obtained locally.

## 5-3. PARTS ORDERING INFORMATION

To obtain replacement parts, contact any of the regional offices listed below and include the part number and description. To ensure that you receive the correct part for your instrument, be sure you include the instrument type or number and its serial and/or model number.

Wilmington, DE 19898
Phone: (302) 772-5575

Newtown, CT 06470
Phone: (203) 426-5811

Monrovia, CA 91016
Phone: (213) 357-2111

64 Wilburg Way
Hitchen, Herts
England
Phone: 0462-52671-4

636 Friedberg/Hessen
Postfach 1410
West Germany
Phone: 06031-4661

*Table 5-1. PARTS LIST*

| Item No. or Ref Des | Part No. | Description |
|---|---|---|
| A1 (figure 5-1) | | Moisture Monitor |
| 1 | 303040 | • Flow Controller |
| BT1 | 203625 | • Battery, 67.5 V, Burgess XX45 |
| M1 | 303132-901 | • Meter |
| S1 | 205284 | • Rocker Switch |
| A1A1 | 303109-901 | • Power Regulator Assy |
| A1R1 (figure 5-2) | 205283 | • • Resistor, Variable, WW, 10 kΩ, 3 W |
| A1F1 | 205224-011 | • • Fuse (Slow-blow), 125 mA, 250 V |
| A1T1 (figure 5-1) | 303124 | • • Transformer |
| A1A2 | 303110-901 | • Printed Circuit Assy, Power Regulator |
| A1A3 | 303114-901 | • Printed Circuit Assy, Attenuator Switch |
| XE1 | 901051-903 | • Cell Case |
| 2 | 303033 | • Cell Cap |
| E1 (figure 5-3) | 303029-901 | • Electrolytic Cell |
| 1 | 303027-901 | • • Filter disc |
| 2 | 202813-006 | • • Seal-O-Ring, 2.89 mm (0.114-in.) ID |

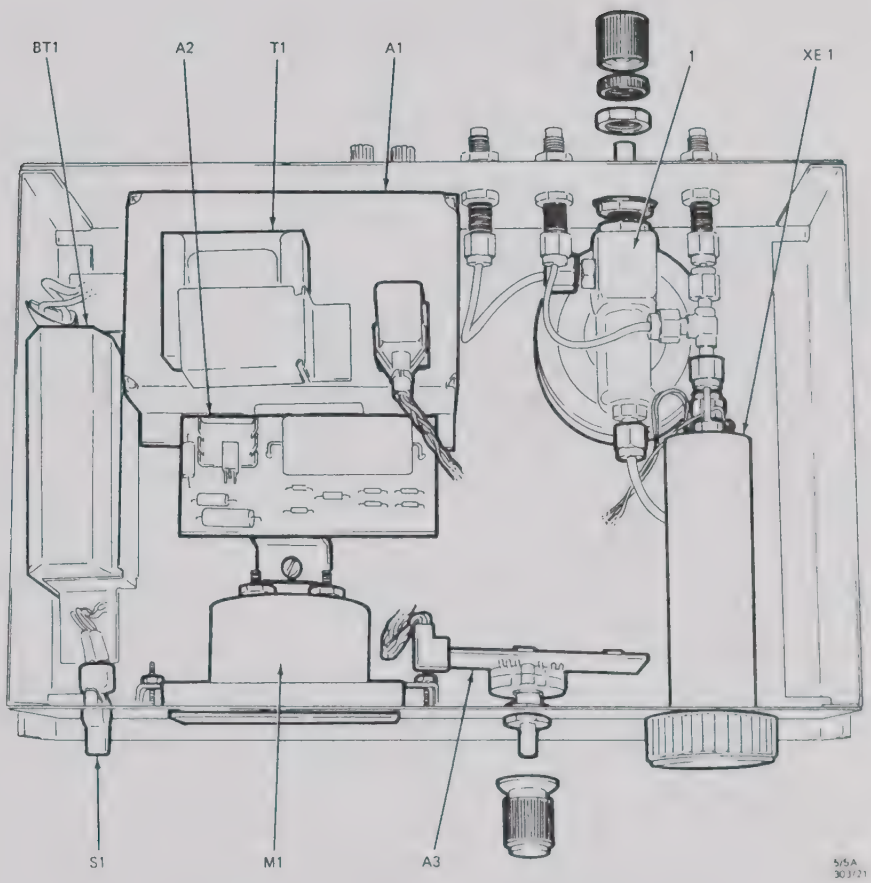



*Figure 5-1. Moisture Monitor, Interior View.*

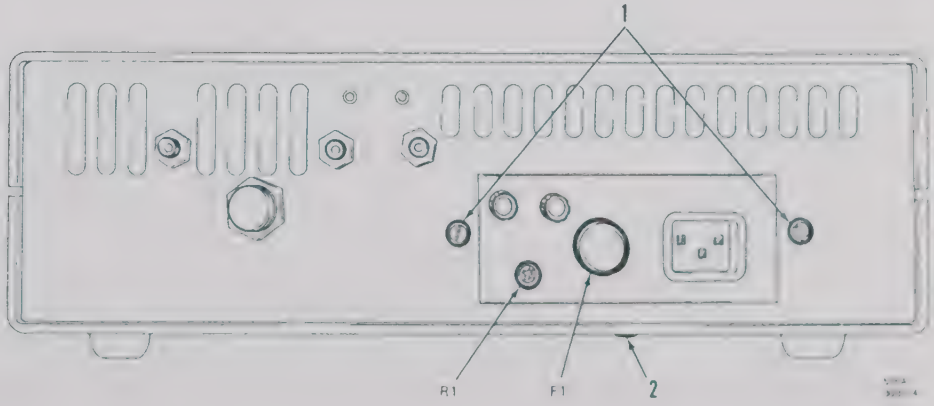



*Figure 5-2. Moisture Monitor, Rear View.*

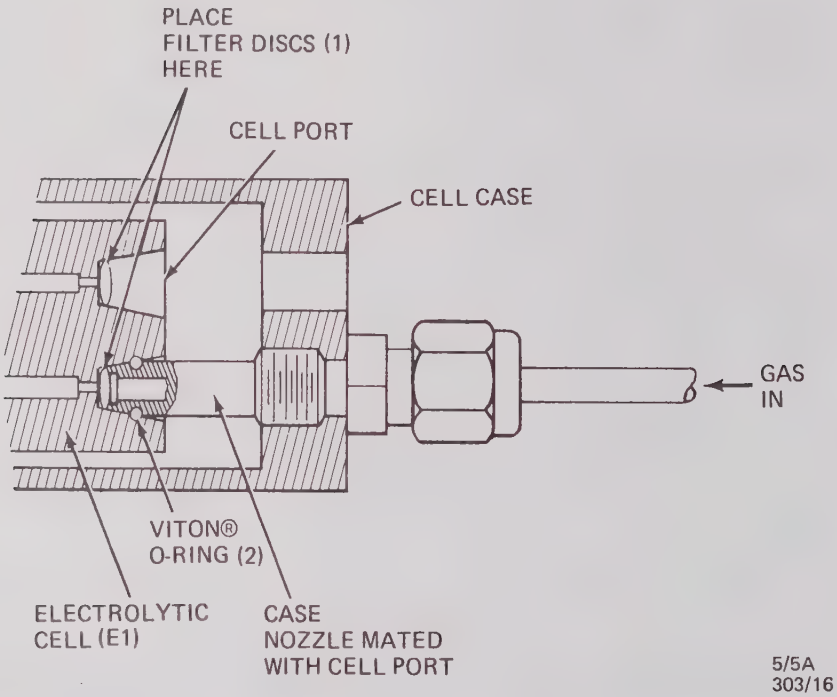



*Figure 5-3. Cell and Case Assembly.*

# APPENDICES

## APPENDIX A

## THE ELECTROLYTIC CELL

A-1. The physical construction of the Du Pont electrolytic cell is shown in figure A-1. The carrier gas with the moisture enters the cell through one of the ports in the Teflon® end piece, passes through the length of glass tubing inside the cell, and exits through the other port. Secured inside the glass tubing are two parallel, helically-wound platinum wires. Between these wires, the electrodes, a thin layer of phosphorous pentoxide is deposited on the glass. The wires are brought out through the leak-tight seals to the electrical contacts in the Teflon® end piece.

A-2. The assembly is cased in epoxy resin for mechanical protection. This normally excludes damage from any cause except objects which may enter through the cell ports. For this reason, never insert any object such as a probe, syringe needle, wire, into the small hole at the bottom of the port leading into the cell. This invariably destroys the cell.

A-3. In an analyzer, the cell converts the water-content of the sample gas to an electrical current. The cell determines the moisture by absorbing this gaseous water on the thin film of phosphorous pentoxide deposited between the two electrodes. A dc voltage on the electrodes electrolyzes the absorbed water into molecular hydrogen and oxygen. Since phosphorous pentoxide is extremely hygroscopic and the cell is designed for intimate contact of gas with the absorbing film, all of the water vapor is absorbed and electrolyzed. This accounts for the high degree of accuracy and specificity, since the process is virtually unique for water and consumes at least 99.9% of the gaseous water at levels as low as 1.0 parts per million or as high as 10 000 parts per million.

Expressed simply as possible, the chemical and electrochemical reactions occurring are:

$$H_2O(g) + P_2O_5(s) \rightarrow P_2O_5 \cdot [H_2O] \text{ x electrolysis (cell current)}$$
$$\uparrow \qquad\qquad \downarrow$$
$$P_2O_5(s) + H_2(g) + 1/2\ [O_2(g)]$$

A-4. If the flow of a sample gas with a specific moisture content is constant the moisture is absorbed and electrolyzed producing a constant current. When the flow is increased the electrolyzing current increases proportionately. The current is directly and linearly related to mass flow and can be calculated from Faraday's Law.

A-5. When these factors are considered for water being electrolyzed by a moisture cell, the current in microamperes per parts per million of water is given by 1 = (0.132 x flow) $\mu$A where the flow is the sample flow in $cm^3$/min, measured at 1 bar (1.00 atm) pressure and 25°C. For example, at 20 $cm^3$/min, 1 part per million of water produces 2.64 $\mu$A; 100 $cm^3$/min, 13.2 $\mu$A.

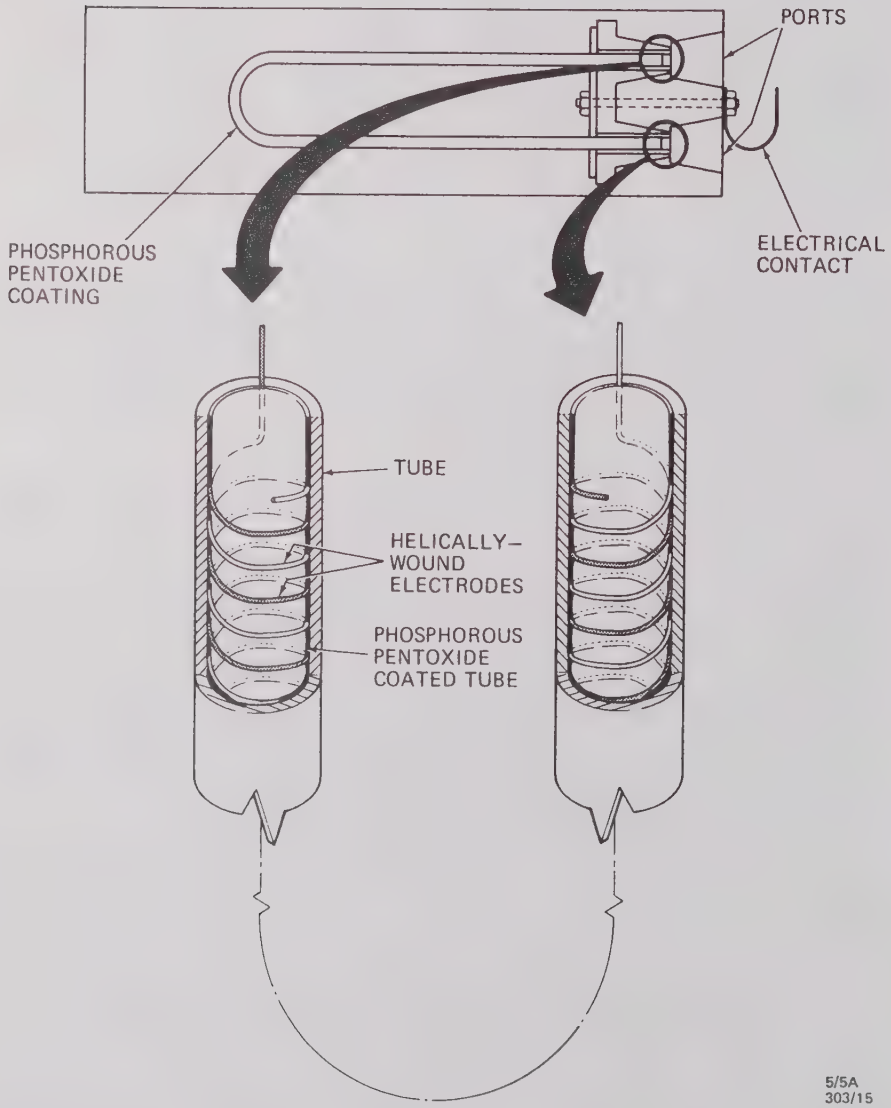
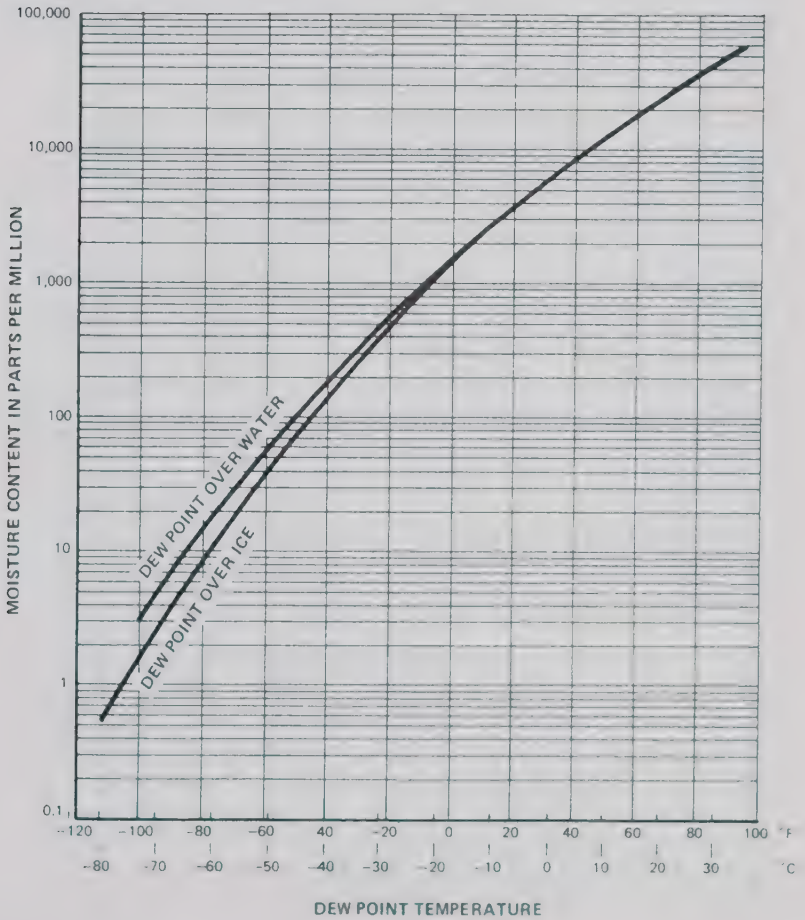



*Figure A-1. Electrolytic Cell.*

## APPENDIX B




The graph relates absolute moisture levels, as obtained on the moisture monitor to dew point in either °F or °C.

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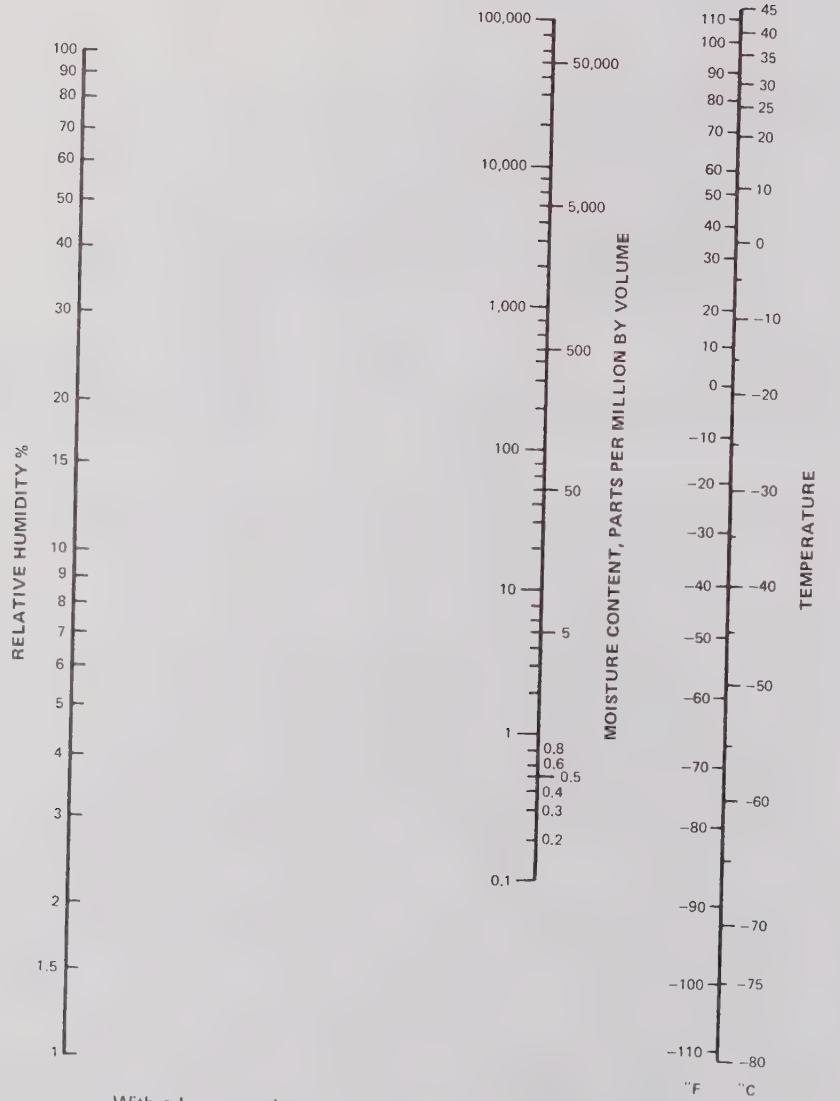
*Figure B-1. Conversion Chart (Parts per Million $H_2O$ to Dew Point).*

## APPENDIX C




With a known moisture content in parts per million at a given temperature, place a straight edge across these values on the proper scale. read the value of relative humidity where the extended straight edge crosses.

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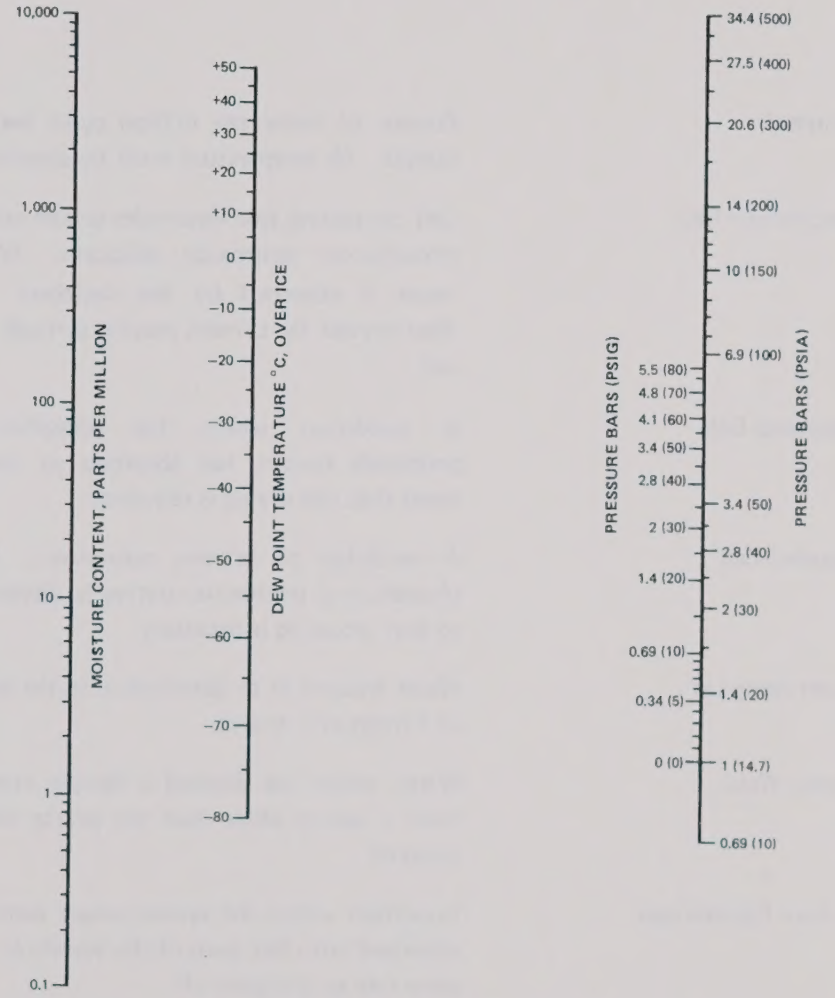
*Figure C-1. Nomogram, Conversion of Parts Per Million $H_2O$ to Relative Humidity.*

## APPENDIX D




Align straight edge on the known moisture content (in parts per million) and pressure points. Read dew point where the straight edge crosses.

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*Figure D-1. Nomogram, Determination of Dew Point with Pressure.*

## APPENDIX E

## GLOSSARY OF ABBREVIATIONS AND SPECIAL TERMS

| | |
|---|---|
| lb/mmcf | Pounds of water per million cubic feet of sample. (A temperature must be specified). |
| Electrolytic Cell | Cell containing two electrodes coated with a phosphorous pentoxide desiccant. Water vapor is absorbed by the desiccant and electrolyzed by current passing through the cell. |
| Saturated Cell | A condition where the phosphorous pentoxide coating has absorbed so much water that cell drying is required. |
| Flooded Cell | A condition of extreme saturation. The phosphorous pentoxide coating is dissolved, so that recoating is necessary. |
| Water Hang-Up | Water trapped in or absorbed onto the walls or fittings of a system. |
| Tramp Water | Water which has entered a sample stream from a source other than the source being sampled. |
| System Equilibrium | Condition within the system where water is absorbed onto the walls of the system at the same rate as it is given off. |
| Entrained Dirt | Dirt carried by a sample stream. |
| Dew Point ($H_2O$) | The temperature at which water vapor begins to deposit as liquid. |
| System Response Time | The sample system volume divided by the flow. |
| Speed of Response | The time for the moisture analyzer to reach 63% of its final reading after a step change in moisture content. |

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